Gouley's operation. Fifth day: Tube taken out permanently, and a No. 25 French sound passed. Patient up and about. Ninth day: All urine passed by the urethra. Fourteenth day: Wound cicatrized. Two and one-half years after operation this patient takes a No. 30 French sound with ease, urination is normal, and the urine practically clear.

CASE III.—Patient aged forty-five years. One traumatic stricture, admitting a filiform, at bulbo-membranous junction. Ammoniacal cystitis. Gouley's operation. Second day: Tube taken out, washed and replaced, and a No. 28 French sound passed. Fifth day: Tube removed permanently. Patient up. Tenth day: All urine passed by urethra. Sixteenth day: Wound cicatrized. Two years after the operation this patient takes a No. 30 French sound with ease, urinates normally, and his urine is clear, with a few light flakes.

CASE IV.—Patient aged twenty-three years. Three dense gonorrhœal strictures; two in pendulous urethra, admitting Nos. 15 and 17 French, respectively, and one in bulbous urethra, taking a filiform. Very severe urethro-cystitis. Internal and external urethrotomy. Third day: Tube taken out, washed, and replaced, and a No. 27 French sound passed. Fifth day: Tube removed permanently. Seventh day: All urine passed by urethra. Patient up and about. Fifteenth day: Wound cicatrized. Two years after operation patient takes a No. 30 French sound with ease, his urine is clear, and urination normal.

A REPORT ON SIX CASES IN WHICH THE BACILLUS AËROGENES CAPSULATUS WAS ISOLATED.

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THE occurrence of gas in the living tissues and the presence of gas after death in larger and smaller bubbles in the viscera, especially in the liver, has long been known, and the cause and significance variously interpreted by clinicians and pathologists. The appearance of the viscera when riddled with gas-bubbles is so striking and peculiar that they are described by the Germans as "schaumorgane," foam-organs. In some instances air embolism was held accountable for the condition, especially when occurring after surgical operations or after childbirth. It was suspected by others that anaërobic bacilli, wandering out of the intestinal canal after death, give rise to the gas productions. It was thus held to be a form of post-mortem decomposition, and little attention was directed to it until the appearance of an article by Welch and Nuttall in 1892.[1]

With the anaërobic bacillus, which they isolated in pure culture from the organs of their case and which they described and named the bacillus aërogenes capsulatus, they were able to reproduce in the tissues of dead rabbits, after distribution of the bacilli through the circulation *intra vitam*, a complete picture of the so-called "schaumorgane" of the Germans. The causal relation between this condition and the bacillus was thus thoroughly established. Animal experimentation further convinced them that to produce such a general and extensive emphysema of the organs and tissues as was present in their case it was necessary to inject the bacilli during the continuance of the circulation, injection into the bloodvessels after death being followed only by an emphysema along the direct course of the vessels inoculated. This noteworthy fact, and the appearance of necrosis and degeneration in the tissues around the masses of bacilli and gas-cysts in the organs of their case, led them to suppose that a terminal infection with the bacillus had taken place. Except in its application to a very limited class of cases, the old views concerning the air-embolism were thus destroyed at one stroke. Too great credit cannot be attached to the authors of this article, as it has removed a piece of mediævalism concerning air-embolism from the minds of the medical profession.

To Eug. Fraenkel[2] belongs the credit of bringing out the causal relation between the bacillus phlegmones emphysematosæ and gaseous phlegmons. This bacillus is considered by Welch as identical with his bacillus aërogenes capsulatus. To the classical description of the morphology and cultural characteristics of the bacillus little of importance has since been added, except the discovery of the formation of spores on blood-serum by Dunham.[3]

Since the publication of Welch and Nuttall's preliminary study, and the study of Fraenkel on the bacillus aërogenes capsulatus, many instances of its occurrence have been described. A partial summary of the cases published previous to the year 1896, with further studies on the bacillus aërogenes capsulatus, is to be found in a second paper, not yet completed, by Welch and Flexner,[4] published in the *Journal of Experimental Medicine*, 1896. The association of a well-defined bacterium with the ante-mortem or post-mortem development of gas in the body is now well established, and a large number of illustrative cases is at our disposal, so that the record of new instances of the isolation of the bacilli aërogenes capsulatus would be itself of but moderate value. However, the conditions under which infection with the germ occurs, its full significance either as a primary or concurrent infection, and the relative frequency with which its presence is simply a post-mortem incident, offer such a series of unsolved problems as makes still desirable an increased number of examinations and records of experiments.

The intention of this paper is to give briefly the more important clinical data obtainable in the histories of six new cases examined by the writer, with the bacteriological analyses, microscopical lesions, etc. At the end of the description of each case a brief summary of the cases in the literature having a direct bearing on the new cases will be given, special stress being laid upon the cases which have been described since those summarized in the later more elaborate publication of Welch and Flexner.[4]

The morphology and cultural characteristics of the bacillus isolated from our cases were identical, and, as they resemble exactly the description given by Welch, need only be briefly mentioned. Size of the bacillus is very variable, in general between 2 and 8 microns. Smears made from animal tissue reveal a marked tendency of the bacillus to occur as diplo-bacilli, a thin band of protoplasm occasionally connecting the rods. Long threads have exceptionally been met in preparations from gaseous phlegmons, but these threads have not been seen in the human blood or in preparations made from organs. Grown in artificial cultures, the rods appear thinner and attain a greater length. Stained by Gram's method, the bacilli appear thicker than when stained by Loeffler's solution.

Capsules were best demonstrated by the method recommended by Welch and Nuttall—that is, by fixing with moderate heat, glacial acetic acid being poured on the cover-glasses and replaced by strong aqueous solutions of gentian violet, and mounting in this fluid. The bacilli then appear even broader than when stained by Gram. By this method the capsules were always successfully demonstrated, and appear to have about the same breadth as the rod itself, and the tendency to form square ends is well made out. The protoplasm of the rod, stainable by this method, may be collected at one end of a slightly-tinged mass, the capsule, the rest of the rod being unstained, or both capsule and rod are short, as if cut off sharply at both ends, or again only the ends of the rod are tangible. Shadows are not infrequent, corresponding in size to the breadth of the rod plus the capsule. Welch,[5] in his article in the *Johns Hopkins Bulletin* on the pneumococcus, mentions similar forms for the pneumococcus, and regards them as empty capsules or involution forms. By Loeffler's stain the bacilli stain irregularly. The granular appearance is most marked in specimens obtained from gaseous phlegmons, with a tendency to heal, or where suppuration is present. The bacilli then appear longer, thinner, and are often vacuolated and with irregular borders. By Gram's stain the bacilli retain the stain uniformly, but occasionally a rod decolorizes. Decolorization of the bacilli grown in artificial cultures is more apt to occur. Where the capsules developed on artificial media the bacilli then did not differ in appearance from those occurring in animal fluids. In cultures few involution-forms were met. Grape-sugar gelatin tubes kept for three months, and then examined, showed the bacilli shrunken and thinner. My observations regarding this point are, however, too limited to be of value. Long threads extending nearly the whole length of the field (homogeneous immersion 1-12 Leitz) were met in agar cultures, often markedly curved. But few cultures showed curved rods.

In my cases except that of the gaseous emphysema of the thigh large oval cocci without capsules were met, but were never recovered by culture. Ernst and Kronig have also met similar forms. No indication of the formation of spores was ever noted. The bacillus isolated from the case of hemorrhagic pancreatitis gave an abundant growth on blood-serum; no spores were seen on smears made from this growth, and inoculations from these tubes at various intervals of time failed to give a growth on transplanting. After four days' anaërobic growth the tubes were kept exposed to the air of the room. Perhaps spores are only obtained after complete exhaustion of the media in a hydrogen atmosphere.

Most of the cultures on sugar-agar stabs were incapable of transplantation after a week's exposure to the air. The longest time noted was sixteen days. Cultures capable of transplantation, when inoculated in large amounts, were often without pathogenic power. Unfortunately, none of my cultures was kept in the hydrogen jars for any length of time. A marked feature of the growth of this bacillus in grape-sugar agar was, that the older the generation the less abundant was the gas formation, the growth never being so active as in the first few generations. Coincident with the decrease of activity in growth was the total loss of pathogenicity toward guinea-pigs.

Welch and Nuttall[1] remark "that there were curious and not readily explainable differences in the vitality of the cultures, some being still alive which were under apparently the same conditions and of the same age as those which proved to be dead." This statement was fully confirmed, and no explanation is offered. Plates made from the liver of my third case, containing enormous numbers of bacilli, as revealed by smears, refused to develop but a single colony, whereas the plates of the intestines, using the same media and placed in the same hydrogen jar, were overcrowded. This incident was not an exceptional one.

DESCRIPTION OF THE COLONIES, AND CULTURAL CHARACTERISTICS. The colonies, when overcrowded on sugar-agar pour-plates, are small, very dark, granular, and have branching projections; gas is almost always present.

The deep colonies, when less crowded, have a slightly yellowish tinge, and when seen by transmitted light after two days' growth appear rather large. They are mostly ovate or elliptical, opaque, and have a purplish tint; the edge is, for the most part, sharply defined and regular, but sometimes shows a fluted border, distinctly granular along the periphery. When the colonies reach the surface the growth spreads more or less evenly. The centre of the colonies is dark and is apt to be opaque, color shading off to a pale brown. The translucent and transparent portions of the colonies show a distinctly wavy, linear, and granular texture. The edge, in many cases, is pale, very regular, and sharply-defined; in other colonies single bacilli or chains of bacilli may be seen extending from the periphery of the colony, and clumps of numerous isolated bacilli, forming whitish streaks of growth, are met frequently on the bottom of the plates. Superficial colonies occasionally have a marked silky appearance.

The bacillus grows well in all the ordinary media.

In bouillon marked turbidity and a whitish deposit soon form, fluid settling and becoming clear after four days of growth.

On slant glycerin-agar growth occurs in the form of well-isolated colonies, the largest several millimetres in diameter. Colonies are whitish, show little tendency to become confluent, and the larger colonies have a slightly yellowish centre. With a Leitz three lens the individual rods on the edges are easily made out.

No growth was obtained on slanted coagulated egg albumin.

On potato, marked gas formation. Surface is wet; growth invisible, or in shape of slightly-yellowish colonies, or a thin whitish film spreads over the whole surface of potato. Condensation water is turbid and frothy. A very persistent stale-glue smell is observed on all the tubes. This odor is noticed on the hands after examination of the tubes, even before removal of the cotton plugs.

Milk coagulates on or before forty-eight hours' growth at 37° C. The coagulum, pierced by air-bubbles, floats on the surface of a clear serum, which is very acid. Coagulæ of smaller size adhere to the sides and bottom of the tubes. On shaking, clot sinks to the bottom. The growth is very characteristic.

Abundant growth in semi-fluid hydrocele fluid, with marked gas formation. No odor of putrefaction and no spore formation observed.

Two per cent. grape-sugar gelatin tubes, inoculated while fluid, allowed to cool and kept at room temperature, show numerous colonies, well isolated, appearing an inch below the surface. They increase in size toward the bottom of the tubes, where they attain a diameter of 3 to 4 mm. Gas is developed first on the third day, and becomes marked on the fifth.

Stab-gelatin tubes develop growth only along lower half of the puncture. Tubes after three to four months show slight signs of liquefaction. No spores observed. Sugar-agar tubes inoculated when fluid show a very marked development of gas.

On slant-lactose litmus agar-tubes there is a marked production of acid, with discrete colonies having reddish centres. Discoloration is prompt, complete usually after four days of growth. Gas is always found in the agar under the surface. On exposure to air the medium become reddish in a few minutes. No indol formation in Dunham's solution.

CASE I.—*Placenta Prævia Marginalis.* Post-mortem invasion by the gas bacillus. Housewife, multiparæ, admitted to the Sloane Maternity Hospital, November 16, 1896.

History. On October 25th patient lost about a pint of blood suddenly, and went to bed, where she remained. No further hemorrhage until November 8th, when slight bleeding occurred, and since then a little blood was lost each day. On admission patient was found to be close to full term. Child of good size, fœtal heart good. Cervix soft, admitted almost two fingers. Vaginal secretion abundant. Small lobes at the edge of the placenta could be felt, marginally at the left and anteriorly, the vertex being felt through the membranes on the right. No bleeding occurred from time of admission until delivery. Patient was apparently in good condition. Pulse, however, was not strong, and woman showed signs of blood loss. Podalic version, prolapse of cord, and extraction of child. Podalic version in two minutes from L. O. A. to R. S. A. easily accomplished. Membranes were then ruptured with intention of pulling foot through the cervix and leaving the patient to expel the child slowly. Very little hemorrhage (10 or 11 ounces) occurred during version, rupture of membranes. When finger sought anterior foot, it was found that child was riding on cord, which was inserted on the margin of the placenta. An attempt to dislodge the cord only resulted in its prolapse. Cord was pushed up as high as possible. A leg was pulled through the cervix. Ten minutes later, as child's heart was feeble, traction on both feet was employed and child was delivered in six minutes. Child was found to be asphyxiated. At the end of nine minutes placenta was expressed on account of hemorrhage. Not more than a pint of blood was lost in third stage. After a vaginal douche, 1–5000 $HgCl_2$ at 116° F., no more bleeding occurred. Laceration of right side of cervix extending into right fornix. Patient went into a condition of shock. Two and a half hours after delivery a hot saline infusion was given—Oiij in median cephalic vein. Three and a half hours later another infusion was given and patient vomited a large amount of fluid. Not more than 4 ounces of blood was reported as lost since delivery; half an hour later another infusion was given. At 8.15, half an hour later, woman was examined, and about 10 ounces of blood-clot removed from vagina. No rupture of uterus was made out, and the organ was found well contracted. Uterus and vagina were then packed with sterile gauze. Death at 9.30, five hours after delivery. Cause of death seemed to be shock due to rapid extraction, as the amount of blood lost was not more than 30–32 ounces. Child remained alive.

Autopsy by Dr. Ewing, twenty-four hours post mortem. Body that of a large fat woman, distinctly anæmic, no œdema. The right broad ligament and the tissues of the right pelvic region around kidney in mesocolon and over a considerable area of the mesentery are very emphysematous and infiltrated with fresh clotted blood. Peritoneal surfaces intact. A large irregular laceration is found involving the entire right portion of the os, extending from one to one and a half inches above the internal os, completely through the uterine wall and into the tissues of the broad ligament. Below it extended one inch into the vagina. Tissues of the uterus are flabby, otherwise normal. Two small hemorrhages are present in posterior wall of bladder. Firm adhesions over both lungs, which are moderately congested and œdematous. Heart chambers empty and flaccid. Beneath the endocardium are seen minute air-bubbles. Valves normal; slight atheroma of aorta. Spleen extremely flabby and emphysematous. The liver is flabby and very pale. The surface is dotted with larger and smaller air-vesicles which extend below the surface, and similar air-vesicles are present throughout the organ. Inferior vena cava and hepatic veins are distended with frothy fluid.

Kidneys flabby, capsule free, surface smooth, except for a few medium-sized air-bubbles. In places there are areas filled with fluid resembling pus. There is a marked diminution in the amount of blood in the body. The blood which exudes from the veins at site of infusion contains no gas.

Anatomical Diagnosis. Rupture of uterus, acute anæmia, pulmonary œdema.

Smears from the liver, spleen, and uterus show large bacilli, apparently in pure culture. Capsules could be stained only by Welch's method.

Pour-plates, with dilutions, were made from the liver, spleen, and uterus on sugar-agar and grown in anaërobic jars at 37° C. The original plate of the liver shows several large air-bubbles, and, examined with a low power, it is seen to be overcrowded with numerous black colonies with branching processes. Colonies seem to be of one kind. Dilution-plates present pure cultures of the bacillus aërogenes capsulatus. The plates from the uterus and spleen reveal similar colonies.

Animal Inoculations. A guinea-pig inoculated subcutaneously in abdomen with 1 c.c. of bouillon in which a bit of the liver had been crushed develops a large fluctuating swelling, which breaks through the skin, with escape of a hemorrhagic fluid. Animal dies in four days, much emaciated. On section, hair with epidermis peels off readily. Whitish necrotic masses of tissue are found over the whole of the abdomen and thorax. Smears reveal typical large bacilli, retaining Gram's stain; also numerous smaller rods which do not accept the stain. Microscopic examination of the organs was negative.

A guinea-pig inoculated with 0.8 c.c. of the hemorrhagic fluid of the phlegmon develops promptly a swelling, which breaks through the skin three days later, with escape of hemorrhagic fluid. After ten days the front of abdomen and thorax has been converted into a suppurative and bleeding area. Animal dies in three weeks, much emaciated. On section, organs macroscopically appear normal, and cultures from heart's blood, aërobic and anaërobic, remain sterile.

A third guinea-pig inoculated subcutaneously with 0.2 c.c. of the same hemorrhagic fluid develops no local effects, and remains alive.

A rabbit was inoculated intravenously with 1 c.c. of a sugar-bouillon culture, grown for three days in a hydrogen atmosphere; it was killed a few minutes later, and its body placed for twenty-two hours at 37° C. On removal, body is found tremendously swollen, crepitation is everywhere present. On section, the subcutaneous tissues and all the organs are emphysematous. Smears reveal the presence of large capsulated bacilli.

A second rabbit was inoculated with the same culture, but kept at room temperature. On section, no emphysema or gas in any of the tissues or organs; marked post-mortem softening. Smears made from the heart's blood reveal a few large bacilli; cultures remain sterile.

A third rabbit was inoculated intravenously with a pure culture, twenty-four hours old, representing a third generation, killed at once and placed at 37° for twenty-four hours. Body is much swollen and eyeballs project out of their sockets; crepitation and emphysema of the subcutaneous tissues. Liver is transformed into a granular, reddish mass. Gas is present in all the organs and vessels. Cover-slips reveal large capsulated bacilli, and by anaërobic culture of the heart's blood an abundant growth is obtained.

A fourth rabbit was injected intravenously with 3 c.c. of the same bouillon culture. No reaction observed, and remains alive. Animal is killed five days after inoculation, and body kept at 37° C. for seventeen hours; body was then found markedly swollen; gas is present in subcutaneous tissues, but not to so marked an extent as in former rabbit. Scrotum much swollen and emphysematous. Gas is present in all the larger vessels. Liver much softened. An anaërobic culture from heart's blood remains sterile.

The portal of entry in this case was undoubtedly the uterus. There was a rupture of the uterus through which the bacilli could readily obtain an entrance into the tissues during life. The bacilli need not have been introduced during the act of childbirth or version, but may have found the bleeding uterine cavity a suitable soil for growth, or at least existence, before labor occurred. Dead tissue, represented by the blood-clots in the uterine cavity, forms a favorable medium for the growth of the bacillus.

The presence of gas was especially marked around the uterus, the mesentery, and inferior vena cava, less so in the liver. This fact, and the long time after death at which the autopsy was performed, point to a post-mortem invasion of the bacillus and not to a terminal infection or even to an entrance into the general circulation during the death agony. Considering the late autopsy, one would otherwise expect subcutaneous emphysema to have developed. The microscopic sections of the liver show no evidences of a vital reaction around the bacterial emboli. The cells present no signs of degeneration, and their nuclei stain well. Around the gas holes there are no changes, except those due to pressure.

CASES PREVIOUSLY DESCRIBED. In the last few years quite a number of interesting cases have been reported of infection through the genital tract, following upon abortion or during or after childbirth. The most important is that of Graham, Stewart, and Baldwin.[6] The patient was a laboring woman, married, aged thirty-five years. About fourteen hours before death the woman, who had been previously well, was seized with what she described as a severe chill, which lasted more than four hours. This was followed by pain in the region of the ovaries and uterus and by vomiting and purging. She was seen by Dr. Stewart at 1 P.M., five hours after onset of the first symptoms. There was extreme restlessness, distress, and pain in the lower abdominal region, and a slight flow of bright-red blood from the uterus. Abortion was suspected. Her pulse was 120. Morphine was administered hypodermically. At 3.30 P.M. she appeared much relieved and dozed off to sleep. At 9.30 P.M. Dr. Stewart found her "emphysematous from the top of her head to the soles of her feet." Emphysematous crackling could be felt over entire surface of body. There was a diffuse, blood-red color of the whole surface of the body.

A case described by Dalton,[7] although the exact identification of the bacillus is not positive, is considered by Welch as belonging to a class of cases due to the gas bacillus, resembling Graham's case in that in both a criminal abortion had probably occurred. Present illness began a month ago with general malaise and muscular lassitude, menstruation came on and lasted one day, followed by intense headache and costive bowels. About one week ago vomited greenish matter several times. No appetite, tongue coated, liver enlarged and tender. Patient is jaundiced. Whole right pectoral region and arm are swollen and crepitate on palpation. Considerable pain in right breast and arm; respiration hurried and deep. Passages loose. Menstruation present. Many small punctures were made in right breast to allow escape of accumulated gas, having an odor of hydrogen sulphide. Respiration became rapid and difficult, lips and fingers cyanosed, extremities cold; emphysema extended up to neck and almost over entire chest. Died on third day after admission. Post-mortem twelve hours after death by Dr. Bremer. Crepitation of subcutaneous tissues obtainable in throat, thorax, abdomen, and upper extremities. Chest, right shoulder, and neck were puffy and discolored. All the organs were emphysematous. Uterus, 10 cm. in length, contained dark-colored material of the consistency of jelly; fetid odor; tissue firm, but crepitateed and floated in water. Reddish-brown clots in heart, which crepitated. The body was swarming with what he calls organisms. Dalton concludes that the bacillus of malignant œdema was responsible for the condition. The patient had produced an abortion on herself once three months ago and again recently, and Dr. Bremer considers the uterus to have been the point of entrance for the organisms.

P. Ernst[8] describes the case of a woman who developed putrid endometritis and septic peritonitis after removal of a macerated four-months' fœtus, the uterus, through doubt as to diagnosis, having been previously curetted, sounded, and tamponed. No development of gas *intra vitam* observed. At autopsy, made three hours after death, the entire uterine wall crepitated. Coagula in the right iliac vein and conus pulmonalis contained gas. Gas found in the myocardium, and especially in the liver, from the cut surface of which gas oozed up, and in a few hours formed a layer of foam several centimetres thick. Disappearance of the nuclei and other degenerative changes in the liver cells around the masses of bacilli led Ernst to believe that the lodgement of the bacilli in the liver took place during life. The development of gas holes in the liver, however, he regards as a post-mortem phenomenon.

Dobbin[9] describes a case in which a patient had been in labor for two days before admission to hospital. The diagnosis was made of a generally contracted pelvis, conjugata vera 8 cm., large child. Position, left occipito-iliac anterior, impacted head, arrest of labor. A frothy, reddish-brown fluid, having a sweetish smell, escaped from the vagina and contained the gas bacilli in great numbers, as well as streptococci. During life no emphysema was detected. The body soon after death began to swell, and bloody, frothy serum exuded from the nostrils with escaping gas-bubbles. The gas bacilli were found in the vaginal discharge, placenta, and fœtus. Examination of the chorion showed that the large vessels were plugged with the bacilli. The villi are described as necrotic, but no sign of reaction on the part of the tissues was noticeable. Seven hours after death body was enormously swollen. No post-mortem.

Dobbin quotes a case of Schnell's—"Ueber einen Fall von Gasblasen im Blut einer nach Tympania Uteri gastorbenem Puerpera." After a prolonged and difficult version, eighteen hours after death the autopsy revealed gas in the heart, lungs, aorta, liver, and spleen. The case is rendered valueless because of Schnell's preconceived ideas concerning air-embolism and his apparent ignorance of the value of a bacteriological examination.

Menge and Kronig,[10] in their elaborate work on the *Bacteriology of the Female Genital Organs*, draw attention to the rôle which anaërobic bacteria play in diseases of the uterus, especially to those puerperal in their origin. Attention need be drawn to only two of their cases, puerperal patients with demonstration of the presence of the gas bacilli in the amniotic waters.

The first case was a primipara, aged twenty-six years, normal pelvis. Pains began February 15, 1894. In evening bag of waters still intact, rupturing next morning. In evening, attempts to deliver with forceps, without avail. After attempts again to deliver with forceps, cephalotripsy was performed. Bad smelling discharge from the vagina. Course of puerperium ran without fever. On the third day secretion of uterus was examined. Aërobic plates remain sterile. Anaërobic culture reveals the gas bacillus. On the ninth day the discharge was no longer badly-smelling, and cultures remain sterile. Although the woman had no temperature or other signs of infection, the perineal wound was not fresh, edges were covered with a grayish-white layer. The tissues in the neighborhood of the tear were necrotic, the resulting tear became three times its original size, and only slowly healed by granulation. Autopsy of child six hours after delivery, the weather being cold. The bacilli were demonstrated on smears and by cultures in the secretion of nose, throat, and armpits. Stomach distended with gas, which burned with a bluish flame and contained a brownish, greasy fluid, evidently the swallowed waters. In the pleura and peritoneal cavities there is a little blood-stained serum. Beneath the pleura pulmonalis, especially over the lower lobes, numerous bean-sized bubbles. Smears from heart's blood reveal thick bacilli positive to Gram's stain. Blood of the cord is sterile. From the lung and stomach the anaërobic bacilli were recovered by culture.

> The second case was a primipara. Hard labor, turning unsuccessful, prolapse of cord. Pains began again after the narcosis. In evening of the same day, temperature 39.6° C., pains have ceased. Abdomen is distended over the uterus; no tympanic note. Fever indicated necessity for extraction of the child. After birth, bad-smelling fluid, with little blood but much meconium escapes. After delivery of placenta uterus was washed with permanganate. Fever disappeared after delivery of placenta. Patient left hospital on ninth day. Lochia examined on sixth day. Numerous cocci and thick rods were found. Aërobic plates remain sterile. Section of child immediately performed. Over lower lobes a few gas bubbles are present beneath the pulmonary pleura. Slight amount of bloody fluid in pleural and peritoneal cavities. Numerous rods present in the liver, lung, less abundant in the kidney and spleen, placental end of cord being sterile. Aërobic cultures from blood and organs, sterile. Anaërobic positive. Sections of the organs by Gram-Weigert method revealed the rods. Kronig describes what he calls a most characteristic rancid-butter smell to the cultures in grape-sugar gelatin, and this odor is noticeably present in the amniotic waters when infected by this bacillus. Dr. Dittel, of the same clinic, by this odor has been able in two other cases to make a preliminary diagnosis of their presence.
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> Kronig has obtained by sterile catheters the amniotic waters from feverish puerperal patients; in twelve out of fifteen cases anaërobic bacteria were alone present, a strictly anaërobic streptococcus being not infrequently found; twenty-one cases were examined in all, three being thus sterile.
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> In a case of labor which became septic after delivery the writer isolated in pure culture a strictly anaërobic streptococcus from the very bad-smelling lochial discharge a week after delivery. No other species present, either aërobically or anaërobically. It resembled the ordinary streptococcus pyogenes longus in its morphology and bouillon growth. It apparently possessed little or no pathogenic powers upon rabbits intravenously injected, and was identical with the streptococcus isolated by Kronig. Three generations were grown on glycerin and grape-sugar agar. The aërobic streak and pour-plates always remained sterile. Death four weeks after delivery with an empyema. From the exudate and lungs the ordinary streptococcus pyogenes was alone obtained in cultures made after the autopsy. One side of the cervix and uterus was converted into a suppurative phlegmon. Bacteriological examination of the pus revealed the streptococcus and a large facultative anaërobic bacillus, with colonies resembling most strikingly those of the bacillus aërogenes capsulatus.

Menge and Kronig identified the bacillus they isolated from their cases completely, and it is refreshing to observe that they were completely familiar with the original article of Welch and Nuttall as well as Fraenkel's monograph, *Ueber gas Phlegmonen.*

Lindenthal[11] (*Zur Aetiologie der sogenannter, Kolpohyperplasia cystica*) isolated an anaërobic bacillus from a case coming to autopsy, resembling that of Welch. He believes it to be the cause of the gas cysts in the vagina, which occur especially after labor. Injection of pure cultures into the cellular tissues of the vagina reproduced the lesion in guinea-pigs. The gas production was most marked in a guinea-pig whose body had been allowed to stand a few hours before the section was made.

The bacillus, which he unnecessarily names the bacillus emphysemæ vaginæ, he believes belongs to the group or is a variety of the bacillus of malignant œdema. It, however, possesses no spores or motility, takes Gram's stain, and produces a fatal gaseous emphysema with sero-hemorrhagic exudate after subcutaneous injections in guinea-pigs and in mice. In rabbits a hard induration or an abscess forms after subcutaneous inoculation. Intravenous injections in only one out of a series of six rabbits were followed by death. Intra-abdominal inoculation in rabbits was negative; in guinea-pigs, two out of four succumbed from a slightly seropurulent peritonitis. Lindenthal is disinclined to consider his bacillus as identical with Welch's or Fraenkel's bacillus. The absence of capsules is not important evidence against its identity, for, although apparently familiar with Welch's work, he ignores or probably never employed his staining method. Although the writer has been able at times to stain the capsule of the bacillus aërogenes by the two methods Lindenthal employed, as a rule with these methods capsules were not demonstrable. No mention is made of his having employed the body of the dead rabbit as a culture medium or for diagnostic purposes. From the marked points of identity as described in his article, I am led to believe them to be identical.

Lindenthal[12] has reported the bacteriological examination of four cases of tympania uteri. The same bacillus was isolated. Cultures injected into the uterus after opening of the peritoneum gave rise to a condition similar to tympania uteri in guinea-pigs. He is disinclined to believe that the bacillus coli communis, in the absence of a sufficient amount of sugar, can induce the same amount of gas production in tissues. His attempt at experimental reproduction of the lesion with the colon bacillus was unsuccessful.

Welch believes that the colon bacillus is not capable of inducing the amount of gas production in the tissues which is such a marked characteristic of the bacillus aërogenes capsulatus.

In two cases in which gas was present in the tissues at autopsy, where the gas production was not due to the bacillus aërogenes capsulatus, this opinion of Welch's is borne out. In a case of traumatic seropurulent peritonitis, following a rupture of a duodenal ulcer, running a latent course, post-mortem, eighteen hours after death, the bacteriological examination of the exudate revealed the colon bacillus and the streptococcus pyogenes. Between the muscular layers of the abdominal parietes there was a moderate amount of emphysema and crackling on pressure which extended into the cellular post-peritoneal tissues. The gas bacillus was not recovered on smears from the exudate or emphysematous tissues, and anaërobic culture, as well as inoculations into rabbits killed shortly afterward, failed to reveal it. From the emphysematous abdominal walls the colon bacillus was isolated. In a second case, a late autopsy on a case of arteriosclerosis, there was a slight emphysema of the cellular tissues over the lumbar muscles. A bacillus resembling the colon bacillus was isolated in pure culture. In both cases evidence of gas in the circulation and organs, although most carefully looked for, was missing.

To summarize briefly the cases here cited of Graham and Dalton, the local infection was followed by a systemic or ante-mortem infection. In Dobbin's case, although definite proof is lacking, little doubt can be held that such a terminal invasion of the bacilli took place. P. Ernst's case must also be held as analogous in this respect to Dobbin's. In the remaining cases cited the bacilli do not give evidence of having gained an entrance into the general circulation, or were rapidly destroyed by the bactericidal or phagocytic powers of the blood and tissues. The variety of the lesions produced by the gas bacillus after infection through the female genital tract is interesting and suggestive of the constant warfare taking place between the animal cells and fluids against micro-organisms. The pathogenic qualities of the bacillus are thus seen to be most varied.

CASE II.—*Acute Leucæmia, Terminal Infection with Bacillus Aërogenes Capsulatus.* Colored man, aged fifty years, admitted to the service of Dr. Delafield at the Roosevelt Hospital, December 17, 1896.

Personal history previous to present illness, negative. For past three months has had pains in joints of upper and lower extremities; last few weeks pain was worse. Complained also of fever, slight nausea, and vomiting. Appetite fair; constipation; insomnia.

On admission, patient is fairly well nourished; pulse fast, but of good force. The right knee is a little swollen and tender. Temperature 100°; pulse 100; respiration 26. Urine acid, 1020; trace of albumin, no sugar; microscopical examination negative. Physical examination on admission reveals subcrepitant râles over the lower part of both lungs. Apical impulse in fifth space inside nipple line. In third left space near edge of sternum there is a harsh systolic murmur and a roughening of first sound. Liver and spleen are negative.

On January 4th patient had a chill. January 5th, temperature in the morning 105°; during the next week temperature ranged between 101° and 103°. After rise of temperature on January 6th there were present signs of fluid or of consolidations over the left lung. During the whole of illness abdomen was tympanitic. Spleen is now felt four inches below costal border. Right leg also reported as swollen.

On January 8th a blood examination was made by Dr. Ewing, who reports the case to be one of spleno-myelogenous leucæmia, the leucocytes outnumbering the red blood-cells. Temperature on 9th rises to 105°. Death on January 10th. Post-mortem, 8 P. M., January 11th, twenty-four hours after death, body having been kept in a cold room.

Post-mortem notes: Subcutaneous tissues over trunk, abdomen, and extremities crepitate. Abdominal cavity is filled with gas which ignites and burns with a blue flame. The mesenteric veins and vena cava are distended by gas; *no signs of peritonitis;* a little bloody serum in peritoneal cavity. Along the mesenteric attachment of stomach and intestines are small split-pea to almond-sized pigmented areas extending to rectum.

Heart in advanced stage of decomposition; no pericarditis or endocarditis.

Lungs slightly congested and œdematous. Bronchial lymph nodes not enlarged. Areas of broncho-pneumonia are present in both lungs.

Spleen: Weighs 26 ounces, is rather firm; follicles are much enlarged. A perisplenitis of a recent date is present. Organ is emphysematous.

Liver: Weighs 4½ pounds; surface and section smooth; color of cut section is dark and slaty; tissues riddled with gas bubbles; markings are obliterated.

Pancreas: Appears much decomposed.

Kidneys: Enlarged and emphysematous. Capsule not adherent, surface smooth and mottled, with petechiæ markings obliterated. Pelvic mucosa is infiltrated with blood.

Stomach: Petechial spots in mucosa. Inguinal and cervical and axillary glands are enlarged and deeply pigmented. Marrow of shaft of femur partly fatty and reddish in color.

Brain: Very anæmic; a few small hemorrhages in the pia mater.

Ribs are very fragile, and their marrow consists of a waxy and homogeneous substance, no red matter being present. Lingual tonsils are a little enlarged and deeply pigmented. Heart's blood watery. A few light-colored clots in right ventricle.

Anatomical Diagnosis: Acute leucæmia, hyperplastic splenitis, chronic lymphadenoma. Cultivations were made from the liver and from the contents of a loop of the small intestines, tied off at both ends at the autopsy. Smears from the liver reveal large bacilli with square ends, with capsule staining by Welch's method. A few cocci and short rods resembling the colon bacillus are also present in small numbers.

In aërobic cultures from the liver numerous colonies of the staphylococcus pyogenes aureus developed. An oval rod was also isolated, giving a whitish stab-growth, with a tendency to spread on the surface.

The anaërobic plates from the liver and intestines developed numerous typical colonies of bacillus aërogenes capsulatus.

By aërobic culture the staphylococcus pyogenes aureus and the colon bacillus were isolated from the contents of the intestine.

Animal Experimentation. A piece of the liver dropped in bouillon and left in thermostat overnight; next morning bouillon is black, and much gas is present around the piece of liver. Cover-glass preparation shows numerous capsulated large bacilli and cocci.

A large, healthy pig was injected subcutaneously in abdomen with 2 c.c. of this bouillon; next morning a large, fluctuating swelling, which, on tapping, emits a splashing sound, is present over abdomen. Crepitation is marked. Death twenty-four hours after injection. Autopsy performed just after death; hair over abdomen epilates easily. Subcutaneous tissues are necrotic and are lifted up from the muscles, necrotic strands of tissue still connecting the layers. These spaces are filled with a slightly hemorrhagic fluid and with gas which escapes. The necrosis extends over whole of front of abdomen and thorax. The odor of the fluid is sweet, but not disagreeable. Abdominal and thoracic muscles are covered with a white pasty necrotic mass. A few ecchymotic spots under the peritoneum. Intestinal vessels are injected and distended. Suprarenals slightly enlarged. In the lungs a few hemorrhagic areas. Kidneys, liver, and spleen appear normal. Heart cavities are filled with dark, fluid blood. Cultures, anaërobic and aërobic, from heart's blood remain sterile; cover-slips reveal no bacteria. The subcutaneous tissue cover-slips show numerous large capsulated rods. Cocci and also oval rods or cocci in chains, which were seen previously in the liver-smears, are present. The anaërobic plates from the subcutaneous tissues show typical colonies and gas-bubbles.

Injections of the Bloody Exudate. 2 c.c. of the hemorrhagic fluid of the gaseous phlegmon, injected subcutaneously in a guinea-pig (No. 2), caused death in eighteen hours; a fluctuating swelling formed over whole of abdomen and thorax. Section four hours after death reveals extensive necrosis of the muscles of abdomen and thorax, with a hemorrhagic œdema in the dependent portions. A clear and slightly hemorrhagic fluid is present in the peritoneal cavity. Cover-slips of this fluid and from the fluid of the phlegmon, several numerous capsulated bacilli, a few smaller rods and cocci. Intestinal vessels are deeply injected. Spleen not enlarged, and shows small, whitish spots. Smears from the liver reveal numerous capsulated rods. By anaërobic culture the bacilli are recovered from the heart's blood, liver, and phlegmon; by aërobic culture, the staphylococcus pyogenes albus.

2 c.c. of the hemorrhagic fluid of pig 2 inoculated in pig 3 caused a gaseous phlegmon, with death in forty-eight hours. Similar postmortem appearances. Smears from the phlegmon reveal several large capsulated bacilli and numerous cocci.

2 c.c. of the hemorrhagic fluid of pig 3 injected subcutaneously in pig 4. Next morning a hard swelling, size of a large walnut, has formed at site of the inoculation. Death in thirty-six to forty hours.

Pig 6 receives 1.5 c.c. of the hemorrhagic fluid of pig 4. A hard swelling forms at site of inoculation, death occurring in four days. Little hemorrhagic fluid is present.

These successive inoculations from pig to pig were employed with the view of increasing the virulence of the bacillus and to obtain the toxins either by filtration of the hemorrhagic fluid contained in the phlegmon or in artificial cultures after inoculation by bacilli of a higher degree of virulence. We were not successful, because the quantity of hemorrhagic fluid decreased from animal to animal. We were also never dealing with pure cultures, but the series was continued, as it seemed the easiest way to keep the bacilli virulent and alive.

Inoculation of Pure Cultures. Pig 5 received the whole of a forty-eight-hours' growth in a stab-agar tube, showing marked development of gas. Animal develops a gaseous phlegmon, which, later, becomes hard and breaks externally. An extensive area of suppuration is formed, extending over the dependent portion of abdomen and thorax. Cicatrization completed two weeks later. Animal dies later from marasmus.

Second Series of Inoculations from Animal to Animal. Pig 7 received 2 c.c. of an emulsion in sterilized salt solution of an actively-growing forty-eight hours' old culture, representing a third generation from the liver, in a sugar-agar stab. Gaseous phlegmon develops promptly; lives nineteen and one-half hours. Autopsy held at once after death. Much hemorrhagic fluid has collected between the skin and muscular layers in a sac occupying the whole of the thorax and abdomen. Axillary and inguinal lymph-nodes are reddened and hemorrhagic. The muscles of abdomen and thorax are intensely congested, the whitish necrosis here being confined to site of inoculation and of limited extent. Some clear fluid in peritoneum; spleen not enlarged; kidneys appear swollen; urinary and gall-bladders are distended. Liver somewhat enlarged; lungs normal; both chambers of heart in diastole and filled with dark, fluid blood. Pericardium contains clear fluid. Hair of abdomen epilates easily. Both horns of uterus contain two fœtuses. Hanging-drop from subcutaneous fluid shows enormous numbers of large rods which are *non-motile*. These rods show very slight Brownian movement.

Cultures. All anaërobic plates on sugar-agar allowed to grow three days before being examined. The subcutaneous plates reveal typical growth in original and in both dilutions.

Urine. Original shows typical superficial and deep colonies controlled by smears. *Bile* and blood of heart, sterile. *Spleen* plate sterile, but a melted sugar tube at 40° shows a few large colonies at bottom of tube. *Kidney* plate sterile; a stab-tube reveals a growth, however. *Liver* plate, numerous colonies and large gas bubbles. Presents a pure culture. A smear from the subcutaneous fluid reveals capsulated rods, and chains of short but thick rods are numerous. Smears from pericardial fluid and from heart's blood, spleen, and liver negative. In peritoneal fluid a few capsulated rods. Plates on plain agar from the heart's blood, after three days at 37° C., remain sterile.

Pig 8 inoculated with 0.5 c.c. of same emulsion that pig 7 received on 23d at 4 P.M. Died during morning of 25th. Autopsy about eight hours after death. The skin of abdomen is raised by a soft fluctuating swelling, which is readily movable; in places crepitation is made out. Gas in swelling ignites with a bluish flame and detonates slightly. Epilation of hair does not readily take place as in pig 7. Rosy-colored fluid and necrosis are present. Pericardium and peritoneum contain a little clear fluid. Adrenals are not hemorrhagic. Spleen slightly enlarged; Malpighian bodies are more prominent than usual. Heart dilated, dark, fluid blood in both chambers.

Cultures. Plain agar plates grown aërobically, after five days at 37° C., from the subcutaneous tissue, the blood of the right heart, the liver, kidney, urine, and spleen, remain sterile.

Anaërobic cultures on sugar-agar; all plates allowed three days of growth at 37° C. Bile and urine sterile. Liver plate sterile; a stab, however, shows growth. Kidney and spleen plates develop typical colonies with gas bubbles. Right heart plate sterile; stab from both auricles shows growth, smears revealing typical rods. Subcutaneous tissue overcrowded; original growth in both dilution plates. Peritoneum, a characteristic stab growth in sugar-agar in pure culture.

Pig 9. 25th, 2 P.M., received 1.5 c.c. of subcutaneous hemorrhagic fluid of pig 8. Next morning animal appears well, but has quite an extensive collection of fluid on one side, near site of inoculation, which moves on pressure, and on tilting abdomen a gas bubble is seen to move upward and downward; over site of bag of fluid superficial layers of epidermis and hair have peeled off. Died morning of 27th. Section 12 M., 27th, body during morning being kept in cold storage. Post-mortem appearances similar to those above described. Aërobic cultures of kidney, liver, and right heart's blood are sterile. Spleen plate is badly contaminated, also the plates from the subcutaneous fluid. Anaërobic culture; blood from right heart sterile. Spleen plate, numerous colonies of bacteria. The hemorrhagic fluid, original, and first dilution plate show a pure culture of the bacillus aërogenes capsulatus. Smears from peritoneum reveal a few capsulated rods; from the hemorrhagic fluid, large rods alone. The bile, liver, kidney, and amniotic fluid are sterile. A stab in sugar-agar from left heart shows in a pure culture. Urine plate contains twenty-five colonies in pure culture.

Pig 10. Injected subcutaneously, at 3 P.M., 27th, with 1 c.c. of the slightly-turbid hemorrhagic fluid of pig 9. Weight, 402 grs. Soft, movable swelling, with gas and crepitation, is soon felt. Found dead at 8 A.M., 28th. Weight, 413 grs. Section three hours later; some extensive undermining of the tissues. Slight amount of fluid in pericardial and peritoneal cavities. Heart filled with dark, clotted blood. Lung shows a few hemorrhagic areas. Liver and kidney normal. Left adrenal blackish, almost no cortex being visible. Spleen normal. Uterus contains four small fœtuses.

The aërobic cultures were contaminated from unsterilized plates.

Anaërobic culture: Kidney, spleen, and liver plates were sterile.

Bile, urine, and blood of right heart reveal a growth. Subcutaneous tissue, typical rods, but also other smaller rods have grown.

Rabbit 1. 1.5 c.c. of the hemorrhagic fluid of pig 10 injected intravenously at 11 A.M., 28th. At 1 P.M. rabbit was lying on its belly; does not rise on poking it. 3.15 P.M., found dead; abdomen then hard and swollen. Two and a half hours later crepitation is felt over whole surface of body. The frothy, blood-tinged fluid oozing from nostrils contains, at this time, large capsulated bacilli. Body, kept at room temperature overnight, is found tremendously swollen. All the organs markedly emphysematous. Blood and tissue fluids contain enormous numbers of rods.

1.5 c.c. of the hemorrhagic fluid of pig 10 injected subcutaneously in abdomen at 11.30 A.M., 28th, into pig 11; found dead at 8 A.M., 29th. Crepitation over swelling is present. At one place the muscular layer has been thinned; so that an opening between the peritoneum and the phlegmon may exist. Intestines and stomach show intense injection of their vessels; reddish fluid is present in the peritoneum, but no whitish exudate. Organs normal in appearance.

Anaërobic culture: Three days' growth at 37° C. Right heart and kidney are sterile. Liver shows overcrowded colonies, a pure culture apparently. Urine, numerous typical colonies develop. Aërobic plates from the liver are overgrown with a bacillus resembling the colon bacillus.

The subcutaneous plates, aërobic and anaërobic, are overgrown by a greenish growth. A smear of peritoneal fluid reveals numerous typical rods recovered by culture, also oval cocci and a few thinner rods.

Rabbit 2. Injected intravenously with 0.2 c.c. of the peritoneal fluid of pig 11, at 1.15 P.M., 29th. Several hours later animal is quiet. Found dead next morning. The body is much swollen, and crepitation is everywhere present. Emphysema of all organs and vessels. Peritoneum distended with gas, burning with a bluish flame.

A Third Generation in Sugar-agar Thirteen Days Old. 1.5 c.c. of an emulsion in sterilized salt solution of a culture containing the bacilli in enormous numbers was injected subcutaneously in each of two pigs. Pigs reactionless. Bacilli stained well and gave a growth on transplanting.

Other attempts to produce, with pure cultures, an emphysema in guinea-pigs were made, with negative results.

In this case terminal infection with the bacillus aërogenes capsulatus seems probable. The abdominal symptoms, pain, tenderness, and tympanites, which became very marked several days before death of the patient, made the diagnosis of peritonitis a probable one, and this diagnosis was entertained, although no cause could be assigned for it; but no peritonitis existed. Emphysema of the subcutaneous tissues, *intra vitam*, was not observed, but no especial attention was paid to this point.

Sections of the liver show larger and smaller gas-holes which are empty. The bacilli are collected around the periphery of these cavities. Evidences of compression of the liver cells surrounding the gas-holes are present. These cells are converted into a mass of badly-staining protoplasm, the outlines of the individual cells being only occasionally made out. Nuclear staining is absent. Where the cells are not so badly disturbed there is vacuolation.

The masses of bacilli are situated mostly in the central veins, and evidence of gas is not always seen. The cells surrounding these bacterial masses show the same loss of nuclear staining and vacuolation. In places the portal vessels contain bacilli. The characteristic large bacilli, staining beautifully by Weigert's method and also by hæmatoxylin, were alone noticed. In the capillaries between the liver cells are seen a few isolated bacilli; toward the periphery of the bacterial emboli they are more numerous. Some of the large hepatic veins contain fibrinous clots or thrombi, with but few bacilli.

The whitish areas of necrosis, with small central gas-holes observed and described by Ernst in one of his cases, were carefully looked for in the liver, macroscopically, but were not present. In the first case of Ernst the autopsy was made three hours after death, and it seems not unlikely that had our case come to autopsy at so early a time similar appearances might have been noted. The change described above in the liver cells, the areas of necrosis surrounding the bacterial growths, in our case never extending quite the whole breadth of an acinus, have been considered by Ernst and by Welch and Nuttall as indicative of a vital process produced by the toxic products of the growth of the bacilli. The liver was also the seat of a marked congestion of the capillaries. It seems most probable that the bacilli gained entrance into the portal circulation through the intestinal coats, which, perhaps, were impaired by a venous congestion, and found in the slow circulation of the mesenteric and hepatic veins a suitable soil for development, giving rise to the abdominal symptoms. The presence of thrombi in the hepatic veins would have favored their growth, the blood in the portal circulation being thus more than ever poorly oxygenized.

The tissues of the small intestines are necrotic, everywhere invaded by myriads of bacilli, and have undergone so much post-mortem change that a further examination was valueless. The kidneys in places are the seat of a marked leucæmic infiltration. The bacilli are in masses inside the bloodvessels and in the tufts. A few casts and bacterial masses are present in the collecting tubules. The parenchyma around most of these bacterial plugs appears unaffected, but in places there is for a considerable distance a loss of nuclear staining. No vacuolation is present. Otherwise the kidney presents the appearance of a parenchymatous degeneration. The spleen shows evidences of compression and necrosis in the cells around the gas-holes. Similar areas are present in the vicinity of the bacterial plugs.

The absence of cocci in the sections of the liver, and their presence by culture in the contents of the small intestines, lead to the opinion that the cocci gained entrance to the liver after death.

Without wishing to lay special stress on the point, it is interesting to note that Dr. Ewing, in examining the blood smears stained by eosin and methylene-blue, prepared three days before death, found a few large bacilli. It is to be regretted that no cultures were made of the blood during life.

Similar Cases of Suspected Terminal Infection. In July, 1895, Goebel,[13] in an article "Ueber den Bacillus der Schaumorgane," confirmed the work of Welch and Nuttall, and identified his bacillus with the bacillus phlegmones emphysematosæ of Fraenkel. He also comes to the conclusion that in two of his cases there was a terminal infection.

The first case was one of pyelonephritis consecutive to papilloma of the bladder and abscesses of the prostate and seminal vessels. Gas-blebs were found in the heart muscles, liver, spleen, adrenals, and stomach.

Around many of the blebs in the heart and liver the cells were necrotic. In the spleen necroses were not present around the gas-blebs. The lesions in the liver were nearly similar to those described by Ernst in the livers of one of his cases. He concludes that the disappearance of the nuclei and degenerative changes around the masses of bacilli point to a vital process and not merely to a post-mortem change. The portal of entry, he concludes, on account of the frequent catheterization before death, to be the genito-urinary tract.

The second case was one of enlarged prostate in a man, aged sixty-six years. Frequent catheterization was necessary. The post-mortem diagnosis was emphysema pulmonum, pneumonia lobularis, embolia art. pulm. lob. inf. sin., and arteriosclerosis universalis. Numerous gas-blebs were found beneath the mucous membrane of the urinary bladder. Necroses were absent from the walls of these blebs. Capsules were demonstrated in smears from the gas-blebs of the bladder. In cultures these capsules were absent, except in one instance. He holds that the invasion in the bladder-walls was a post-mortem phenomenon, on account of the absence of the vital changes in the bladder above described.

The third case was one of pyæmia following endophlebitis of the cutaneous veins of the left foot. Beneath the gastric and intestinal mucosa were gas-blebs resembling those in the preceding case, except that necroses were present around the blebs. The intestine he considers to be the portal of entry for the bacilli. Evidences of gas were absent, except in one of the femoral arteries. The experiments of Welch and Nuttall were repeated with identical results both with the bacillus isolated from foaming organs and with that from gaseous phlegmons. Necroses were absent from the walls of gas-holes developing in the organs of dead rabbits. Spores were present in one culture, a stab forty-eight hours old, in a sodium formate agar-tube. Liquefaction of gelatin with cultures from Case I. was slow and limited; with those from the second it was rapid and marked. Subcutaneous inoculation of guinea-pigs was followed by fatal gaseous phlegmons.

CASE III.—*Hypertrophic Cirrhosis.* Dr. Norrie, assistant physician; Dr. McClellan, house physician. Patient, aged fifty years; admitted February 6, 1897; died February 7, 1897.

Personal History. Markedly alcoholic. Patient was well up to two months ago, when he began to complain of pain in right side. For past three weeks has had dyspnœa and insomnia. Three days ago suddenly began to vomit large amounts of clotted blood. Blood in stools. Œdema of feet the last four days. Apex in fifth space inside of nipple line; action rapid and regular. Systolic murmur in third and fourth space close to border of sternum. Lungs negative. Liver, from fifth rib to free border, edge not felt. Abdomen large; superficial veins are prominent; abdomen tympanitic. Pulse rapid, regular, and of good force. No tension. On day of admission said to have had bloody expectoration; vomited a few ounces of blood. Patient became weaker, delirious, and died with signs of œdema of lungs. Urine was bile tinged, otherwise negative.

Post-mortem by Dr. Norrie, twenty-seven hours after death. Large frame, adipose abundant. Rigor mortis is present. All the subcutaneous tissues are tremendously inflated with gas, which escapes and burns with a bluish flame. Foul odor. A number of discolored blebs filled with serum are situated on the thighs and trunk. Face is much swollen and discolored. Gas and blood bubble out of mouth. Scrotum much swollen with gas. Heart weighs sixteen and one-half ounces and is dilated; valves normal. Post-mortem change very marked. Both lungs are congested.

Liver weighs six and one-quarter pounds; its surface is rough, and consistency very firm. On section, lobules stand out prominently. The liver is fatty and cirrhotic. Bubbles of gas escape on section. Spleen about eight inches in length, very soft. Kidneys show marked post-mortem change. Stomach filled with clotted blood. Mucous membrane is much congested.

Anatomical diagnosis: hypertrophic cirrhosis of liver; dilatation of heart. At the laboratory liver was found to be large and firm, and of a blackish-green color; crepitation on pressure, and on standing at room temperature crackling is heard.

Cultures were made from the liver and from a loop of small intestine tied off at the ends during the autopsy. Cover-slips from liver show the characteristic large rods, with well marked capsules, staining by Welch's method and by nearly all, except Gram's, stains. Diplococci more or less lancet-shaped and staining by Gram's stain, also thinner rods negative to Gram are seen, and large coccus or oval forms in chains positive to Gram. Smears from the intestinal contents show large capsulated rods in great abundance. Shadows are also seen which do not stain, except along a narrow edge. The vast majority of the bacilli present can be identified as the bacillus aërogenes capsulatus.

A piece of liver was crushed up in salt solution in a test-tube; 1.5 c.c. of this solution was inoculated intravenously in a rabbit, and the same amount subcutaneously in a pig; next day the pig had developed a hard, elongated swelling over front of abdomen, extending well up over chest. Three days after inoculation the skin over the swelling had ruptured. Animal does not appear sick, and eats well. After eight days cicatrization is present, but the wound exudes still a little bloody fluid. Animal recovers.

The rabbit, a few hours after injection, appears quiet. Twenty-four hours later the animal is killed, and the body is left overnight at room temperature. Crepitation next day is apparently felt. The body is then placed three hours at 37° C. On section no gas was present. Cover-slip from peritoneum and blood reveals rods resembling the colon bacillus. No cultures made. Post-mortem softening is marked. In this case twenty-four hours' sojourn in the circulation of the rabbit was sufficiently long to kill the bacilli.

Aërobic plates on plain agar from the liver. Original is overcrowded with colonies, apparently of one kind. First dilution plate shows colonies of one kind, resembling the pneumococcus. Deep colonies are grayish-white; under lower power are nearly black. Surface colonies have a light-bluish color and are nearly transparent. Under lower power are granular, the centres being dark and edge beaded. Smears from numerous colonies reveal a coccus positive to Gram, mostly in chains, many distinctly lancet-shaped. Size of cocci varies slightly. Bouillon inoculated from these colonies gives a whitish sediment and a slight diffuse cloudiness. Milk coagulates between forty-eight and seventy-two hours. Stab-gelatin tube shows a growth after three days, consisting of small, isolated, and whitish colonies. No surface growth and no liquefaction after fifteen days. Smears reveal streptococci and diplococci. A mouse inoculated intraperitoneally with an emulsion of salt solution from numerous colonies on original plate shows no reaction, and lives.

The streptococcus was identified as one of those forms which cloud bouillon.

The anaërobic plates on sugar-agar from the liver; original is overcrowded with small colonies, dark in color, with characteristic branching projections, and gas develops on second day. Smears reveal threads and long rods, the short, thick rods observed in the liver smears not being present.

By aërobic culture from the contents of the intestines were isolated the colon bacillus and a diplococcus resembling that recovered from the liver.

The anaërobic plates, the original, develop colonies of the bacillus aërogenes capsulatus and the bacillus coli communis. The second dilution plate presents a pure culture of the former.

The portal of entry for the bacilli in this case would seem, although this is not susceptible of definite proof, to have been the intestinal tract, probably a post-mortem invasion through the patulous and ruptured œsophageal veins.

Animal Inoculations. Pig 1 inoculated subcutaneously with 1.5 c.c. of a turbid bouillon culture, grown anaërobically for four days, develops a few hours later a soft, fluctuating swelling, which is tender to the touch and crepitates. Death in thirty-six hours. Typical post-mortem appearances. Cultures were made several hours after death. The aërobic cultures on plain agar from all the organs and from the fluid of the phlegmon are sterile. The gas bacillus was obtained by culture from the blood of the left heart, peritoneum, urine, and the hemorrhagic fluid. Right heart, liver, kidney, and the gall-bladder sterile.

Pig 2. Inoculated with a like amount of same culture, develops a gaseous phlegmon which breaks externally. The swelling is surrounded by a hard induration which extends over part of thorax. Animal slowly recovers.

Pig 3. 1.5 c.c. of the slightly-hemorrhagic fluid from pig 1 was injected subcutaneously in pig 3; several hours later a small swelling, freely crepitating, has formed, which rapidly enlarges and becomes soft and fluctuating. Death in less than forty hours. Same post-mortem appearances. Hemorrhagic fluid does not present a pure culture, cocci being seen on the smears. Autopsy several hours after death. Anaërobic cultures from the urine, hemorrhagic fluid, and peritoneum alone show a growth of the gas bacillus, the organs and heart's blood being sterile.

Aërobic plates from the spleen, liver, kidney, and right heart's blood are sterile.

The aërobic plates of the hemorrhagic fluid contain numerous colonies resembling those of the colon bacillus. In making inoculations to determine the cultural characteristics of this bacillus it was observed that a milk-tube, grown aërobically, presented after forty-eight hours a firm clot floating on the surface of a clear serum, and it emits a strong smell of stale glue. Smears reveal large capsulated rods, also rods resembling those taken from the colony. A second milk-tube inoculated from this milk-tube revealed a similar appearance after forty-eight hours' growth. Typical colonies developed by anaërobic cultivation. Inoculation from these colonies refused to grow aërobically. This occurrence shows the ability of the anaërobic bacillus to grow under aërobic conditions in the presence of anaërobic bacilli belonging to the colon group. In fishing the aërobic colony a few rods, which were present in the media, were carried over into the milk-tube with the aërobic bacilli.

Rabbit 1. 1.5 c.c. of the hemorrhagic fluid from subcutaneous tissue of pig 1 was injected intravenously. Half an hour later rabbit dies suddenly with violent clonic convulsions. Soon after death abdomen becomes hard and tense. Crepitation develops after a few hours in the subcutaneous tissues, and the bloody froth oozing from nostrils contains the bacilli four hours after death. Next morning body is still more swollen. All organs and tissues are riddled with gas bubbles. Smears reveal large rods with capsules staining by Welch's and by Luepke's method. No cultures were made. Body floats lightly on surface of water. Death was probably due to embolism.

Rabbit 2. A large buck-rabbit receives intravenously, at 2.45 P.M., 1.5 c.c. of same bouillon culture which was used to inoculate pigs 1 and 2. Temperature 102.2°. No effect noticed. Animal remains alive.

Rabbit 3. Receives a like amount of the same bouillon culture; killed at once and left at room temperature. Body becomes swollen in a few hours. Next morning body is tympanitic, gas present everywhere. Gas ignites with a slight report and a bluish flame.

50 c.c. of gas contained in the peritoneal cavity collected and, by analysis, is found to consist principally of HCO_2 and small traces of CH_4.

Pig 4. 0.3 c.c. of the hemorrhagic fluid of pig 3 injected in subcutaneous tissue of abdomen of pig 4 causes a swelling which shows fluctuation and crepitation. Death six days later. Skin has nearly broken through centre of the swelling, the edges of which are infiltrated and hard. Section a few hours after death; anaërobic culture of blood, urine, and organs fails to reveal the gas bacilli. The aërobic bacilli present in the hemorrhagic fluid injected are recovered by culture in all the organs, bile, blood, and hemorrhagic fluid.

The Effect of the Toxins developed in Artificial Culture of the Bacillus Aërogenes Capsulatus. To determine the character and amount of toxins produced in artificial culture media, a half-litre of 2 per cent. grape-sugar bouillon was inoculated from one of the colonies on the anaërobic plates from the intestine. The flask placed for two weeks at 37° C. in an anaërobic jar. Cloudiness of bouillon after twenty-four hours, fluid becoming clear after four days, and there is formed a considerable whitish sediment. Supernatant fluid was decanted off and filtered through porcelain filters by Dr. Prudden.

A large hare, weighing 2130 grs., received intravenously 8 c.c. of this fluid, warmed to a temperature of 37° C., 2 c.c. being injected at intervals of five minutes. After injection, respirations are labored and hurried.

Temperature per rectum before inoculation 102.8° F. Temperature per rectum three-quarters of an hour later 103.4° F. Animal quiet. Ears cold. Three hours after injection, temperature 104.6° F. Four and one-twelfth hours after injection, temperature 103.1° F. Twenty-three hours after injection, 102° F. Ears warm. Weight 2080 grs. Little effect was thus noted.

White rabbit; weight, 1848 grs. 13 c.c. at 37° C. were injected intravenously, fluid being at body temperature. Temperature before inoculation, 101.8° F. One hour later, temperature 103.5° F. Ears warm. Animal apparently unaffected. Fifty hours after injection, temperature 100.8° F.; ears and body warm. Rabbit appears sick, but remains alive.

Guinea-pigs. A guinea-pig receives 6 c.c. of the filtered toxin subcutaneously. Temperature before injection 101.2° F.; one hour later, 96.8° F. Hair of shoulders and neck stands erect, abdomen is tender to the touch, and the animal lies on its side, trembles, and strokes mouth with its paws. Temperature three hours after injection 100.7° F., and the pig is still shaking. Twenty hours later, entirely recovered; temperature 101.9° F.

A second pig receives intraperitoneally 12 c.c. Before inoculation, temperature 101.8° F.; one hour later, temperature 95.4° F. Animal is very sick and weak, and lies on its side. Hair of shoulders and neck erect, violent shaking. After three hours, temperature 96.8° F. Animal shaking violently. Twenty hours after injection, temperature 102.8° F. Animal has recovered entirely.

These experiments show that the filtered bouillon has a marked toxic action on guinea-pigs, but that little toxic action is apparent after intravenous inoculations in rabbits.

The Effect Produced by Dead Bacilli. To determine the effect of the dead bacilli, the whitish sediment on the bottom of the flask was treated with sterilized normal salt solution, sterilized for half an hour at a time in an Arnold sterilizer for two days in succession; the sediment then failed to give a growth, by anaërobic or aërobic culture. Smears from this sediment gave characteristic rods, about one-half of the bacilli accepting Gram's stain, the other half decolorizing. The sediment was allowed to settle and was washed three times, the fluid being decanted each time.

Subcutaneous injections in guinea-pigs and rabbits were followed by no local effects; intramuscular injections also were negative. These results are in harmony with those obtained by Eug. Fraenkel.

CASE IV.—*Gaseous Phlegmon Following a Compound Fracture of the Right Tibia at its Upper Third.* This case occurred in the service of Dr. Bryant at St. Vincent's Hospital, to whom I am indebted for the permission to publish the case.

On December 17, 1896, the patient, a driver, slipped on the snow, and the wheel of the truck passed over his right leg. He was brought to the hospital in an ambulance. The leg was greatly swollen, ecchymotic, and gave signs of air under the skin just below tuberosity of the tibia. A compound comminuted fracture of the tibia was made out, and from the small wound venous blood continued to escape, even after pressure above had been applied. The thigh just above the knee was badly contused, and the knee-joint seemed to be full of fluid and air. Patient was in a condition of shock, and the foot was cold. Leg shaved at the wound, thoroughly irrigated with bichloride solution, dressed, and splints were applied. Elevation of leg and free stimulation.

18th. Considerable discharge of dark blood in the dressing. Temperature 101°; respiration 24; pulse 104 at 1 A.M. Temperature 104°; respiration 29; pulse 112 at 9 A.M.

19th. Temperature 104.6°. Leg greatly swollen, and several incisions were made, letting out a quantity of dark, offensively-smelling blood. Thorough irrigation with 1:100 carbolic solution, hot carbolic dressings being applied. At 1 P.M. temperature 106°; pulse rapid and weak.

Sponge baths to reduce the temperature, which went to 104.8° in half an hour. Under anæsthesia a few incisions in leg and thigh were made, from which a little blood and some gas escaped. Skin seemed to be filled with gas, little fluid or œdema being present. Drainage-tubes inserted, elevation of foot, and hot carbolic dressings. Free stimulation. Tissues around fractures were gangrenous and circulation in foot was poor.

22d. Patient's condition noted as improved. Several incisions were made in gangrenous part of leg, below the fracture, and continuous irrigation of carbolic solution was allowed to play on the leg. Patient restless and delirious.

23d. Amputation of leg at lower third of femur, anterior and posterior skin flaps being made. Little hemorrhage occurred. Marked weakness after operation. Circulation in leg was so feeble that the flaps were not sutured. The posterior flap was ecchymotic and nearly bloodless.

Temperature after operation 101.6°; respiration 18; pulse 118. Very restless and complained of intense pain at intervals.

24th. Delirious. Dressed twice daily.

26th. Takes nourishment and medicines. Wound filled with sloughy tissues and contains little or no blood.

28th. Died suddenly in the morning.

Temperature steadily rose from time of accident to its highest point —106° F., 1 A.M., December 19th. Course of temperature varied then approximately between 102° to 104° with diurnal variations.

Through the kindness of Dr. W. C. Lusk I was enabled to make the bedside cultivations, four days after the injury and a week before death of patient.

December 21, 1896, deep stabs in sugar-agar and a slant of glycerin-agar were made; the latter, grown aërobically, develops a pure culture of the staphylococcus pyogenes albus. The smears made at the bedside reveal cocci, not in great abundance, and longer and shorter thick rods with rounded ends staining positively to Gram.

The bacilli by Welch's method reveal beautifully stained capsules; by Loeffler's stain they appear somewhat granular.

Two of the four deep stabs gave a vigorous growth with marked gas production along length of the puncture, which is slightly yellowish in color, edges are fluted, and have dark granular spots. Smears reveal large bacilli with rounded ends. Chains of a dozen members are numerous, and also thinner rods of considerable length. Capsules were not demonstrable. No cocci seen on the smears. Four plates develop pure cultures of the bacillus aërogenes capsulatus. As the colonies resembled in every detail those seen in previous cases from organs, a description is superfluous. From some of the colonies smears revealed threads of various lengths more or less bent. These threads were never seen in previous cases, but resemble the threads obtained from the gaseous phlegmons of guinea-pigs. In smears made from some of these colonies capsules were demonstrable. The rods are absolutely immotile.

An emulsion in broth from one of the original stabs injected into a rabbit intravenously. Killed after a few minutes and body kept at 37° C. for twenty-four hours. Body is found much swollen; crepitation and gas are present in all organs, vessels, and subcutaneous tissues.

Smears made from different places reveal capsulated bacilli. The colonies on the pour plates refused to grow further on transplanting.

REMARKS ON SIMILAR CASES. It would extend the limits of this report to go into the literature of gaseous phlegmons, especially those cases in which the colon group has been isolated. A review of Fraenkel's[2] cases has been furnished by Welch and Flexner. Erdman[11] has reviewed and brought together the cases in which the bacillus aërogenes capsulatus was isolated from gaseous phlegmons, but does not include Fraenkel's four cases.

Fraenkel's bacillus corresponds closely with the bacillus isolated in my cases. Fraenkel's cultures at room temperature died in two or three days. He noticed a marked difference in the amount of fermentation, even in media made in the same way. Two per cent. agar interferes with the gas formation. Age of culture does not interfere with the gas production when planted on fresh media. In other cases, with daily inoculations, no gas was formed, a fact also observed by myself. In my experience the older the generation the less was gas produced. Contrary to Fraenkel, my sugar-agar cultures were the ones to develop most smell, and hydrogen sulphide was never formed. Slant blood-serum he recommends as an excellent medium. He did not observe spore formation on this medium, but mentions that he has found spores inconstantly on sodium formate. Gas and fetid decomposition of the serum were produced. Curiously enough, he finds nothing characteristic in the coagulation of milk, gas production being absent. After twelve weeks he was able to reinoculate from a gelatin-stab kept in room temperature, which has remained intact, and he claims that the virulence when tried on suitable media does not diminish.

As regards animals, the pig was the most sensitive. With mice no result. Intravenous injections in rabbits were negative. Subcutaneous injections in rabbits were not regularly attended with local lesions; the lesion produced is different from that observed in man. A rabbit received a twenty-four-hour-old agar culture. Next day there is formed at site of the inoculation an œdematous swelling. After forty-eight hours' swelling is tense and gives pseudo-fluctuation. The general condition of the rabbit unimpaired. Necrosis of skin over swelling occurs slowly and leaves a crater-like excavation, the edges of which are covered with a grayish necrotic tissue. Healing occurs with formation of scar tissue after weeks. Skin in neighborhood of abscess remains hairless. With pure culture no suppuration was ever present. In experiments in which the gas bacilli were injected in combination with streptococci and staphylococcus pyogenes aureus, softening of the muscles always occurs.

In animals the bacilli were never found in the organs, nor any changes microscopically. Dead bacilli, he says, do not protect or cause any local changes of the tissues in pigs, nor does one affection protect from another.

CASE V.—Through the kindness of Dr. Dunham the writer was enabled to make cultivations from another case of "Schaumorgane," reported by him in the *Bulletin of Johns Hopkins Hospital.* The same bacillus was isolated, producing in pure culture, in the bodies of dead rabbits, identical post-mortem appearances. Subcutaneous inoculations in guinea-pigs were not made.

CASE VI.—This case forms the subject of a report by Dr. Larkin[15] read before the New York Pathological Society. It was a case of hemorrhagic pancreatitis with multiple hepatic abscesses. Gas-holes were especially marked in the left lobe of the liver. Post-mortem eight hours after death. From the liver the bacillus aërogenes capsulatus was isolated.

To conclude, pure cultures injected in guinea-pigs subcutaneously often fail to produce any local effects. Only the most actively growing fresh cultures produced a fatal gaseous phlegmon. When the phlegmon breaks externally, the animal usually survives. Sections of the abdominal wall taken from the affected areas show that the process is one of necrosis principally. In no case was there any evidence of suppuration where pure cultures had been employed. The hemorrhagic fluid contains few leucocytes. The organs showed no marked microscopic lesions.

Injections of the hemorrhagic fluid of guinea-pigs into other guinea-pigs produced fatal phlegmons with regularity. Production of gas at site of injection was not infrequently seen in less than an hour after inoculation. Intravenous inoculations of pure cultures (in rabbits) were never followed by any effects. Intravenous injections in rabbits of the hemorrhagic fluid were usually followed by fatal results. As small amounts were injected, it is hard to believe that the fatal results could be attributed to the toxic effect of the serum, *per se.* It seems likely that the bacilli are able to produce much larger amounts of toxin in the body fluids, and to attain here a higher degree of virulence, than in artificial culture media. This conclusion seems justified, as pure cultures are much less virulent than the hemorrhagic fluid of guinea-pigs when injected into other guinea-pigs.

Attempts at filtering the hemorrhagic fluid were unsuccessful, the filters becoming clogged before more than a few drops had run through.

C. Fraenkel found that guinea-pigs which had recovered from the effects of previous gaseous phlegmons, on reinoculation succumbed as quickly as fresh guinea-pigs. The hope, therefore, of finding a protective serum seems not as yet justified.

The bacillus seems to be most widely distributed; but no one has, as far as my knowledge extends, undertaken to find out how often it is present in the intestinal tract, and it has not been found in nature. It has been assigned as the cause of peritonitis, being found in pure culture in the exudate in one of Welch and Flexner's cases. The cases of experimental peritonitis that have been produced by others were characterized by a similar exudate to that described by Welch and Flexner to be present in their case.

The writer cannot help expressing his lively anticipatory interest in the conclusion of the article of Welch and Flexner, which has yet to appear. There are many points referred to by the authors which have not as yet been elucidated.

In conclusion, I wish to express my deep sense of obligation to Dr. Prudden for his kind help and advice, which have always been at my service.

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